

IPW

Docket No.: 200313701-2 US PCT (1509-608)

PATENT



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of

RUDIN, John Christopher

U.S. Patent Application No. 10/587,282

Filed: July 25, 2006

:
: Confirmation No.: 4910
:
:
: Group Art Unit: 2871
:
: Examiner: Not Yet Known

For: COLOUR DISPLAY DEVICE AND METHOD OF MANUFACTURE

TRANSMITTAL OF CERTIFIED PRIORITY DOCUMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

At the time the above application was filed, priority was claimed based on the following application:

Great Britain Application No. 0406317.8, filed on March 20, 2004

A copy of the priority application is enclosed. Acknowledgement is respectfully requested.

Respectfully submitted,

LOWE HAUPTMAN HAM & BERNER, LLP

Kenneth M. Berner

Kenneth M. Berner
Registration No. 37,093

1700 Diagonal Road, Suite 300
Alexandria, Virginia 22314
(703) 684-1111
(703) 518-5499 Facsimile
Date: August 6, 2007
KMB/mkl

Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with patent application GB0406317.8 filed on 20 March 2004.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed



Dated 29 June 2007

Patent Act 1977
(Rule 2)



22MAR04 E882656-1 001463
P01/7700 0:00-0406317.8 ACCOUNT CHA

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

1. Your reference 200313701-1 GB

2. Patent application number 0406317.8
(The Patent Office will fill this part in) 20 MAR 2004

3. Full name, address and postcode of the or of each applicant (underline all surnames)
Hewlett-Packard Development Company, L.P.
20555 S.H. 249
Houston, TX 77070
USA

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

880445 2001

4. Title of the invention
Colour Display Device And
Method of Manufacture

5. Name of your agent (if you have one)
"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)
Richard A. Lawrence
Hewlett-Packard Ltd, IP Section
Filton Road, Stoke Gifford
Bristol BS34 8QZ

Patents ADP number (if you know it)

1933005

6. Priority: Complete this section if you are declaring priority from one or more earlier patent applications, filed in the last 12 months.	Country	Priority application number (if you know it)	Date of filing (day / month / year)
---	---------	---	--

7. Divisionals, etc: Complete this section only if this application is a divisional application or resulted from an entitlement dispute (see note f)	Number of earlier UK application	Date of filing (day / month / year)
--	----------------------------------	--


8. Is a Patents Form 7/77 (Statement of inventorship and of right to grant of a patent) required in support of this request?
Answer YES if:
a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
Otherwise answer NO (See note d)

Yes

Patents Form 1/77

9. Accompanying documents: A patent application must include a description of the invention. Not counting duplicates, please enter the number of pages of each item accompanying this form:

Continuation sheets of this form

Description	16
Claim(s)	6
Abstract	1
Drawing(s)	25 + 23 

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77) 1

Request for a preliminary examination and search (Patents Form 9/77) 1

Request for a substantive examination (Patents Form 10/77)

Any other documents (please specify)

Fee Sheet

11. I/We request the grant of a patent on the basis of this application.

Signature(s)


Richard A. Lawrence 18/03/2004

12. Name, daytime telephone number and e-mail address, if any, of person to contact in the United Kingdom

Tony Judd

Tel: 0117-312-8026

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

- If you need help to fill in this form or you have any questions, please contact the Patent Office on 08459 500505.
- Write your answers in capital letters using black ink or you may type them.
- If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.
- If you have answered YES in part 8, a Patents Form 7/77 will need to be filed.
- Once you have filled in the form you must remember to sign and date it.
- Part 7 should only be completed when a divisional application is being made under section 15(4), or when an application is being made under section 8(3), 12(6) or 37(4) following an entitlement dispute. By completing part 7 you are requesting that this application takes the same filing date as an earlier UK application. If you want the new application to have the same priority date(s) as the earlier UK application, you should also complete part 6 with the priority details.

DUPLICATE

COLOUR DISPLAY DEVICE AND METHOD OF MANUFACTURE

The present invention relates to a colour display device and a method of manufacturing the device.

5

BACKGROUND TO THE INVENTION

Many colour displays operate by combining a colour filter plate with an array of electronic shutters to give
10 controllable selection of e.g. of red, green and blue areas. The colour filter must be aligned or registered with the shutters, must allow through as much of the required colour of light as possible and as little as possible of the unwanted colours. Often the colours are separated by a black
15 matrix, to preserve colour purity in the case of small misalignments, and in particular to shield light from thin film transistors (TFTs) if they are present.

A common arrangement of shutters is a rectangular array of
20 rectangular pixels, though other more complex arrangements have been proposed. The array may be defined on one substrate by an active matrix circuit, where the other substrate has a common ground plane, or by the intersection of row electrodes on one substrate, and column electrodes on the other. In the
25 first case, the colour filter/black matrix must be aligned in two dimensions. In the second case, the colours can be arranged in stripes aligned with the electrode pattern to simplify alignment along the stripe direction. The pixels are usually clustered in groups, typically of three (triads - Red
30 Green and Blue to match the colour receptors of the human eye), making a square 'superpixel' which can display a range of colours, or black and white when viewed from a distance

beyond which the eye can resolve the individual pixels. Other arrangements have been proposed, such as 'quads' of four subpixels - red, two greens and blue for example. These are more difficult to register, as they have to align in both the row and column direction; however they offer several benefits:

- improved appearance of image edges when displayed - sub pixels are square not rectangular
- reduction in the pitch of interconnect in one direction (from 3x superpixel pitch to 2x)
- possible reduction in driver cost from $r+3c$ to $2r+2c$ ($r=\#rows \times \text{row driver cost}$)
- small improvement in overall aperture ($= (\text{interpixel gap})^2$)
- opportunity to improve the colour gamut of the display by adding a fourth colour to R, G and B.

In practice the colour filter plate is expensive to manufacture, and the image quality is strongly affected by this component. Typically the patterns are made by a number of photolithographic steps. Inkjet or similar printing has also been proposed, wherein a series of 'wells' are made (usually photolithographically) which are then filled with colour filter material such as a dyed or pigmented resin. Here the wells have to be registered with the electrode structures.

It has been proposed in US 5,587,818 to form the colour filters on different substrates of a liquid crystal display (LCD). In one embodiment, both the blue filter and the black matrix are formed on the top glass substrate, while the red and green filters are formed on the bottom glass substrate such that the red and green filters are aligned with the blue filter to form the triad. This arrangement is said to allow control of both the width of the black matrix and the size of

the colour filters.

US 5,734,457 describes a colour display that uses a combination of absorptive and reflective colour filters. The absorptive filters are located on the display-side substrate and the reflective filters are located on a face opposite to the display-side substrate. The arrangement is such that each reflective colour filter reflects light having a complementary colour of light transmitted through an absorptive colour filter. The arrangement is said to improve light efficiency at the colour filters, thereby reducing power consumption associated with backlighting.

SUMMARY OF THE INVENTION

15

According to an aspect of the present invention there is provided a colour display device comprising:

a first display substrate and a second display substrate, said substrates being spaced apart and opposed to each other;

a layer of an electro-optic material between the substrates;

a set of first electrodes on an inner surface of the first display substrate and a set of second electrodes on an inner surface of the second display substrate, the first electrodes intersecting the second electrodes to define pixels for selectively applying an electric field across at least some of said electro-optic material;

a set of first colour filters on the first display substrate, each of said first electrodes being in register with one of said first colour filters;

a set of second colour filters on the second display

substrate, each of said second electrodes being in register with one of said second colour filters;

whereby the colour of light transmitted through a pixel is determined by the light transmitted by both the first
5 colour filter and the second colour filter that intersect at that pixel.

The display may provide superpixels and the benefits set forth above. However, each colour filter need be aligned
10 only with one electrode on the substrate carrying the filter.

In a backlit display, the filters nearest the backlight can be made using a reflective filter technology such as a thin film stack, cholesteric liquid crystal polymer or similar,
15 thus recycling the unwanted colour into the backlight assembly for reuse. Normally reflective colour filters have the problem of also reflecting ambient light back to the viewer, thereby reducing contrast. In the present invention the front colour filter can reduce this effect if it is a
20 normal absorbing filter.

If the display has row stripes on one substrate which alternate between two of cyan (C), magenta (M) and yellow (Y), and column stripes which alternate between a different
25 two of those, the arrangement will provide quads of red (R), green (G), blue (B) and whichever of CMY is present on both substrates. We envisage that an embodiment in which yellow is present on both substrates may be the preferred for optimised display brightness.

30

Alternatively, the visible spectrum may be divided into a desired number of regions, for example four regions: R, G, T

(teal) and B. Row stripes may alternate between (R+G) absorption and (T+B) absorption; column stripes may alternate between (R+T) and (B+G) absorption. The four combinations give R, G, B and T transmission.

5

As another example, both substrates may be striped with filters that absorb in each of red, green, and blue transmission (ie, cyan, magenta, and yellow colours). The combination in a three-by-three grid will give nine areas -
10 one each of cyan, magenta and yellow, and two each of red, green, and blue transmission.

The colour filters may be formed on the substrates by any method known in the art. However, a preferred method is to
15 form the colour filters together with addressing busbars on a surface of a transfer carrier, adhere the filters and busbars to the display substrate, and then remove the transfer carrier. By using a transfer carrier with a smooth, planar surface, the filters may be formed on the display substrates
20 without the need for a separate planarising operation.

The electro-optic material changes its optical properties in response to an applied electric field. Suitable electro-optic materials will be well known to those skilled in the
25 art of display device manufacture. The electro-optic material may be a liquid crystal, for example a nematic liquid crystal functioning in a twisted or supertwisted nematic mode, a hybrid aligned mode, dyed guest-host, or any other desired mode. One or two polarisers are typically
30 required to distinguish switched and unswitched states of the liquid crystal.

It is preferred that the electrodes and filters are parallel on a substrate and arranged orthogonally to each other on opposite substrates. Accordingly, another aspect of the invention provides a colour display device comprising first and second spaced apart display substrates enclosing a layer of an electro-optic material, an inner surface of each substrate being provided with a plurality of elongate parallel electrodes and a plurality of elongate parallel colour filters, each filter being in register with an electrode; wherein the electrodes on one of the inner surfaces are aligned substantially orthogonally to those on the other inner surface so that the colour of light transmitted through a location where two colour filters intersect is determined by the light transmitted by both of the filters.

Other aspects and benefits of the invention will appear in the following specification, drawings and claims.

The invention will now be further described, by way of example only, with reference to the following drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1 to 9 illustrate stages in the manufacture of a display substrate having colour filters, busbars and electrode tracks in a predetermined alignment, for use in making a display in accordance with an embodiment of the present invention;

Figures 10 to 13 illustrate stages in an alternative method of manufacture of a display substrate for use in making a display in accordance with an embodiment of the present invention;

Figures 14 to 17 illustrate stages in another alternative method of manufacturing a display substrate for use in a display in accordance with an embodiment of the present invention;

Figures 18 to 21 illustrate stages in a further alternative method of manufacturing a display substrate for use in a display in accordance with an embodiment of the invention;

Figures 22 and 23 are schematic sectional and plan views respectively of a display device in accordance with an embodiment of the invention;

Figure 24 is a perspective view corresponding to Figure 3, illustrating another alternative embodiment of a method of making a display substrate for use in an example of the present invention; and

Figure 25 is a schematic view of a display in accordance with

another embodiment of the invention.

DETAILED DESCRIPTION

- 5 In the drawings, different parts have been enlarged or reduced to aid illustration of the invention. The drawings are therefore not to scale.

Referring to Figure 25, an example of the invention is
10 illustrated with reference to a display comprising a first display substrate 13 and a second display substrate 18. The substrates, typically of glass or a translucent plastics material, are spaced apart and opposed to each other. The substrates enclose a layer of a liquid crystal material (not
15 shown). The display may be a twisted nematic display, which will be viewed through polarisers set either side of the liquid crystal material, or any other desired LCD mode.

A set of parallel first electrode stripes 17a are provided on
20 the inner surface of the first display substrate 13 and a set of parallel second electrode stripes 17b are provided on the inner surface of the second display substrate 18. The first electrode stripes 17a are orthogonal to the second electrode stripes 17b and define pixels at their intersections. Each
25 electrode stripe 17 has an associated colour filter which is in register with it. In this example, the first electrode stripes 17a are registered with alternate cyan (C) and yellow (Y) colour filters, and the second electrode stripes 17b are registered with C and magenta (M) colour filters.

30

The colour of transmitted light through a pixel is determined by the light transmitted by both the first and second colour

filters, as illustrated by the diagram on the right hand side of Figure 25. Overlap of C and M filters produces a blue pixel; overlap of C and Y filters produces a green pixel; and overlap of M and Y filters produces a red pixel. Overlap of both C filters, of course, produces a cyan colour. The combination of pixels (or subpixels) produces a quad superpixel.

The display in this example is backlit by a light source located beneath the second display substrate 18. The colour filters CM associated with the second display substrate 18 may be reflective filters so that unwanted light is recycled back into the backlight assembly, thereby improving operating efficiency. For example, the cyan filter may transmit green and blue light, but reflect (rather than absorb) red light; the magenta filter may transmit red and blue light but reflect green light. The first colour filters (CY in this example) are absorbing filters so that a viewer seeing the display through the first display substrate 13 does not perceive a reduced contrast caused by reflected ambient light. Conventional antiglare or antireflective coatings may optionally also be incorporated in the display to further improve contrast.

A planarising layer 28 is shown on the lower substrate, to give a planar inner surface. However, it is preferred to manufacture the display by a method which does not require the application of a separate planarising layer. A preferred method is discussed below.

A carrier 1 for use in the invention is shown in Figure 1. The carrier 1 comprises a base film 2 on which is coated a

planar, conductive layer 3. The carrier 1 may be rigid or flexible. In this example, the base film 2 comprises 150 μm thick PET and the conductive layer 3 is copper metal of about 1 μm thickness. In this example, the conductive copper layer 3 is optically flat and has been passivated by immersion in 0.1 N potassium dichromate solution for 5 minutes, rinsed with deionised water and air dried.

A multiple-level, controlled-roughness pattern of dielectric structures 4 is formed on the surface of the conductive layer 3 of the carrier 1 (Figure 2). The dielectric material is optically transparent and in this example is formed by micromoulding as taught in WO 96/35971. The dielectric structures 4 are separated from each other by a series of parallel trenches 5, in which the busbars will be formed. Each structure 5 comprises a rough, planar area 6 and a raised levee 7. The planar areas (filter-receiving surfaces) 6 will accept the colour filter layers and the levees 7 will separate the colour filters. The trenches and levees are substantially linear structures which will run across the length or width of the substrate to which they are transferred. They are typically about 100 μm apart and up to many metres in length. The rough planar surfaces 6 will permit spreading of an applied ink jet coating and may optionally be treated to promote wetting. The levees 7 are smooth and may optionally be treated to further discourage wetting and flow of one colour material into an adjacent planar area.

Referring now to Figure 3, conductive material 8 is formed in the trenches 5. The conductive material is preferably a metal and, in this example, is formed by additive

electroforming. It is preferred that the conductor 3 forms the cathode of an electrolytic cell with a nickel anode and standard nickel sulphamate-based electrolyte. Plating may be carried out by DC, with pulsed or biased AC current being used to fill in the trenches completely. Other known electroplating or electroless plating techniques may be employed. Suitable metals include nickel, copper and gold.

The resulting metallised structure is coated with colour filter material (Figures 4 and 5). In this example the material is deposited by ink jet printing in the colour-receiving planar areas 6 to produce cyan 9, magenta 10, and yellow 11 colour filter triads. Other colour combinations may optionally be used. In a preferred embodiment, the colour filter material is a dyed UV-curable resin (Brewer Science, Inc PSC). Examples of suitable inkjet nozzles include thermal and piezo nozzles, although other depositing means and techniques may be used. The alignment of droplets is not critical because the filter material is allowed to spread out across the planar regions 6 and is constrained by the levees 7 from flowing into the adjacent channels. The planar areas 6 are preferably suitably roughened to help the applied colour filter material wet out and key in. The filter material 9, 10, 11 may be cured after coating, for example by UV exposure and/or thermal treatment.

After curing of the colour filters 9, 10, 11, the resulting structure is then treated with a transfer adhesive 12, and the final display substrate 13 is laminated and the adhesive 12 is cured (Figure 6). In a preferred embodiment the transfer adhesive 12 is a UV-curable material such as NOA81 (Norland Optical Products) but may be thermal- or moisture-

cured. The display substrate 13 is preferably a plastics material, for example PEN (DuPont Teijin Teonex Q65), PES (Sumitomo Bakelite) or polyArylate (Ferrania SpA - Arylite), but could comprise glass, preferably a UV-translucent glass.

5

The carrier 1 is then peeled away, leaving the colour filter/busbar laminate shown in Figure 7.

To form electrodes, a transparent conductor 14 is deposited
10 onto the released surface of the laminate structure, as illustrated in Figure 8. The conductor 14 may comprise indium oxide, tin oxide, indium tin oxide (ITO) or the like, but is preferably an organic conductor such as PEDOT:PSS (Bayer Baytron P).

15

The transparent conductor 14 is then selectively etched or patterned to provide transparent electrodes 17. In the present embodiment, illustrated in Figure 9, the conductor 14 is photopatterned by illuminating the laminate from the
20 reverse (substrate 13) side. The colour filters 9, 10, 11 are at least partially opaque to UV, whilst the substrate 13, transfer adhesive 12 and dielectric 4 are not. Consequently, substantially the only UV transparent areas are the raised levees 7. In the preferred embodiment, PEDOT:PSS is bleached
25 directly by the incident UV light to form the electrode structures 17. Alternatively, standard photoresists and etching may be employed, as will be described later.

The resulting display substrate has colour filters, busbars and transparent electrodes in a predetermined alignment. It
30 may be incorporated in a display, for example a liquid crystal display, using fabrication techniques well known per se to those skilled in the art of display manufacture.

Referring now to Figures 10 to 13, a modification of the process is illustrated in which a coatable polariser layer 15a is applied on top of the colour filter laminate structure shown in Figure 5. After curing of the coatable polariser layer 15a, the resulting structure is adhered to a display substrate 13 using a transfer adhesive 12, followed by removal of the carrier 1, application of a transparent conductor 14, and formation of transparent electrodes 17 in a manner as previously described. A suitable coatable polariser material is sold by Optiva, Inc. Coatable polarisers are described in Bobrov, Y., Cobb, C., Lazarev, P., Bos, P., Bryand, D., Wonderly, H. "Lyotropic Thin Film Polarisers", *Society for Information Display, Int.Symp.Digest of Technical Papers*, Long Beach, California May 16-18, 2000, Vol. XXXI, 1102-1107.

The process illustrated with respect to Figures 14 to 17 is similar to that illustrated with respect to Figures 6 to 9, with the difference that the colour filter/busbar structure shown in Figure 5 is adhered to a conventional polariser 15 which is in turn adhered to the display substrate 13. Methods for adhering conventional polarisers to display substrates will be well known to those skilled in the art of LCD manufacture. Other optical films, such as compensation retarders, may also optionally be laminated inside the display without affecting the planarity and performance of the electro-optic layer interface. A benefit of having a polariser on the inside is that a substrate with uncontrolled birefringence may be used.

An alternative method of forming electrode tracks 17 from the

transparent conductor layer 14 shown in Figure 16 is illustrated in Figures 18 to 22. A positive photoresist material 16 (Shipley 1805) is coated on the transparent conductor 14 (Figure 18). UV illumination through the substrate 13 transmits UV light through the levees 7 (Figure 19) thereby curing the resist 16 in regions corresponding to the levees 7. The resist 16 is developed (Shipley Microposit Developer) to remove the exposed material (Figure 20), and the transparent conductor 14 is then wet or dry etched (for example by sodium hypochlorite solution) to produce electrode tracks 17 (Figure 21). Finally, the resist 16 is removed to leave the final substrate with electrode tracks as shown in Figure 17. The resist 16 may be removed by means of standard solvents or a commercial resist stripper, for example acetone.

Because the colour filters are used as a mask to form the electrodes, the arrangement is self-aligning. The electrodes are aligned with the colour filter stripes and of substantially the same size and shape.

Turning now to Figures 22 and 23, an example of an electro-optic display device using a substrate manufactured in accordance with an aspect of the present invention is described. The device is a liquid crystal display (LCD) in this example, but the substrates may be employed in other types of display device. The device comprises a first display substrate 13 and a second display substrate 18, each of which is provided with an adhered polariser 15 in a manner known per se. The structure shown in Figure 17 is provided with an alignment layer 19 for inducing a desired local uniform alignment in molecules of a liquid crystal material

27. The polariser 15 on the second display substrate 18 is affixed to busbars 8b and second colour filters (Y is illustrated here) by a layer of adhesive 15. Lower electrode stripes 17b are formed on the busbars 8b by a similar method for that used for the first display substrate 13. The second electrode structures 17b are also provided with an alignment layer 19. Any desired alignment layers 19 known to those skilled in the art may be used, for example rubbed polyimide. Depending on the type of display mode, the two alignment layers may induce the same type of alignment (for example planar, tilted planar, or homeotropic) or different types. Where both alignment layers 19 produce a planar or tilted planar alignment, the direction of alignment may be the same or different. For example, in a twisted nematic display, both alignment layers may induce planar alignment, with the orientation of the alignments being perpendicular.

The display is provided with a peripheral seal 25 to retain the liquid crystal material 27. In the example illustrated in Figure 23, a plurality of busbars 22 form row-addressing electrodes and a plurality of busbars 23 form column-addressing electrodes. Pixels 26 are defined at locations where row and column electrodes overlap, and characters or other indicia may be displayed in regions where a sufficient voltage is applied across appropriate pixels, thereby modifying the optical behaviour of the liquid crystal in the region of the pixels so that there is a visible difference when the display is viewed between the polarisers 15. The colour which is displayed by any one pixel will be a function of the light absorbed by the first and second colour filters, as previously discussed; for example yellow and magenta filters will combine to absorb blue and green, thereby

producing red light.

Other features known per se may optionally be included in the display by conventional means. Examples include backlights
5 and one or more antiglare layers.

Each busbar 8 need not be in the middle of its associated electrode track 17, but may be located at any desired contact line on the track. In Figure 24, part of a transfer carrier
10 is shown, in which the busbars 8 are formed adjacent to the levees 7 on the planar conductive surface 3. Subsequent UV exposure of a transparent conductor through the levees 7 will result in the busbars being aligned at the sides of corresponding transparent electrode tracks.

15

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention
20 which are, for brevity, described in the context of a single embodiment, may also be provided separately, or in any suitable combination.

It is to be recognized that various alterations,
25 modifications, and/or additions may be introduced into the constructions and arrangements of parts described above without departing from the scope of the present invention as specified in the claims.

30

CLAIMS

1. A colour display device comprising:

a first display substrate and a second display

5 substrate, said substrates being spaced apart and opposed to each other;

a layer of an electro-optic material between the substrates;

10 a set of first electrodes on an inner surface of the first display substrate and a set of second electrodes on an inner surface of the second display substrate, the first electrodes intersecting the second electrodes to define pixels for selectively applying an electric field across at least some of said electro-optic material;

15 a set of first colour filters on the first display substrate, each of said first electrodes being in register with one of said first colour filters;

a set of second colour filters on the second display substrate, each of said second electrodes being in register
20 with one of said second colour filters;

whereby the colour of light transmitted through a pixel is determined by the light transmitted by both the first colour filter and the second colour filter that intersect at that pixel.

25

2. A device according to claim 1, wherein said first colour filters comprise at least two different colours selected from cyan, magenta and yellow, and wherein said second colour filters comprise at least two different colours selected from
30 cyan, magenta and yellow and selected so that any two-by-two array of pixels contains at least one red, one green and one blue pixel.

3. A device according to claim 1 or claim 2, wherein said first colour filters comprise alternating stripes of yellow and cyan and wherein said second colour filters comprise alternating stripes of yellow and magenta.

4. A device according to claim 1, wherein said first and second colour filters each comprise repeating stripes of cyan, magenta and yellow.

5. A device according to claim 1, wherein said first and second colour filters each comprise stripes of a plurality of colours, and wherein the wavelengths of light transmitted by all of said first colour filters or by all of said second colour filters would if mixed produce substantially white light.

6. A device according to any preceding claim, further including a backlight for illuminating the display, located adjacent to an outer surface of said second display substrate; wherein said second colour filters comprise reflectance filters so that at least some of the light which is not transmitted by said second colour filters will be reflected towards said backlight.

7. A device according to claim 6, wherein said first colour filters comprise absorbing filters, whereby incident light which is not transmitted by said first colour filters will be substantially absorbed by said filters.

8. A device according to any preceding claim, wherein each electrode is provided with an associated busbar with which it

is in registration and in electrical contact.

9. A colour display device comprising first and second spaced apart display substrates enclosing a layer of an electro-optic material, an inner surface of each substrate being provided with a plurality of elongate parallel electrodes and a plurality of elongate parallel colour filters, each filter being in register with an electrode; wherein the electrodes on one of the inner surfaces are aligned substantially orthogonally to those on the other inner surface so that the colour of light transmitted through a location where two colour filters intersect is determined by the light transmitted by both of the filters.

10. A device according to any preceding claim, wherein the electro-optic material is a liquid crystal material.

11. A liquid crystal display device comprising:
first and second spaced apart display substrates enclosing a layer of a liquid crystal material, an inner surface of each substrate being provided with a plurality of elongate parallel electrodes each of which is in register with an elongate colour filter of substantially the same size and shape as the electrode with which it is registered and is provided on the same substrate;

the electrodes on one of the inner surfaces being aligned substantially orthogonally to those on the other inner surface so that the colour of light transmitted through a location where two colour filters intersect is determined by the light transmitted by both of the filters;

the device including a backlight located adjacent to an outer surface of the second display substrate, and the colour

filters on the second display substrate being reflective colour filters.

12. A device according to claim 11, wherein the colour
5 filters on the first display substrate are absorptive colour filters.

13. A method of manufacturing a colour display device, comprising the steps of:

10 taking a first display substrate having a set of first electrodes on a surface thereof, each of said first electrodes being in register with a colour filter and a busbar provided on the first display substrate;

taking a second display substrate having a set of second
15 electrodes on a surface thereof, each of said second electrodes being in register with a colour filter and a busbar provided on the second display substrate;

arranging said first and second display substrates in opposition with the surfaces carrying the electrodes facing
20 inwards and spaced apart, and with the first electrodes intersecting the second electrodes to define pixels for selectively applying an electric field therebetween; and

filling the space between the substrates with an electro-optic material and forming a peripheral seal to
25 retain the electro-optic material;

whereby the colour of light transmitted through a pixel will determined by the light transmitted by both the first colour filter and the second colour filter that intersect at that pixel.

30

14. A method according to claim 13, further comprising the step of forming the first display substrate by:

forming said colour filters and said busbars in registration on a surface of a transfer carrier;

adhering said colour filters and said busbars to a sheet of a translucent glass or plastics material;

5 removing said transfer carrier;

forming a translucent conductor layer on said busbars after removal of said transfer carrier, said translucent conductor layer being capable of being rendered substantially non-conductive after exposure to UV light of sufficient intensity and duration;

10 illuminating said conductor layer with UV light of sufficient intensity and duration through said sheet so as to cause substantial loss of conductivity in regions of said conductor layer corresponding to spaces between said colour filters;

15 thereby forming a plurality of translucent electrode tracks, each of which is in electrical contact with a busbar.

15. A method according to claim 13, further comprising the step of forming the first display substrate by: forming said colour filters and said busbars in registration on a surface of a transfer carrier;

adhering said colour filters and said busbars to a sheet of a translucent glass or plastics material;

25 removing said transfer carrier;

forming a transparent conductor layer on said busbars after removal of said transfer carrier;

applying a layer of positive photoresist material to said conductor layer;

30 illuminating said photoresist material with UV light of sufficient intensity and duration through said display substrate as to effect a chemical change in exposed regions

of said photoresist material corresponding to spaces between said light filters;

developing said photoresist so as to remove said photoresist in said exposed regions;

5 etching said conductor layer in regions where said photoresist has been removed, thereby forming a plurality of transparent electrode tracks, each of which is in electrical contact with a busbar; and

removing remaining photoresist.

10 .

16. A method according to claim 14 or claim 15, wherein said surface of said transfer carrier is planar.

17. A method of manufacturing a colour display device
15 substantially as herein described with reference to the drawings.

18. A colour display device substantially as herein described with reference to or as shown in the drawings.

20

ABSTRACT

COLOUR DISPLAY DEVICE AND METHOD OF MANUFACTURE

5 A colour display device comprises:
first (13) and second (18) spaced apart display substrates
enclosing a layer of an electro-optic material (27), an inner
surface of each substrate (13, 18) being provided with a
plurality of elongate parallel electrodes (17a, 17b) and a
10 plurality of elongate parallel colour filters (CY, CM), each
filter being in register with an electrode; wherein the
electrodes (17a, 17b) on one of the inner surfaces are
aligned substantially orthogonally to those on the other
inner surface so that the colour of light transmitted through
15 a location (26) where two colour filters intersect is
determined by the light transmitted by both of the filters.

Fig. 25



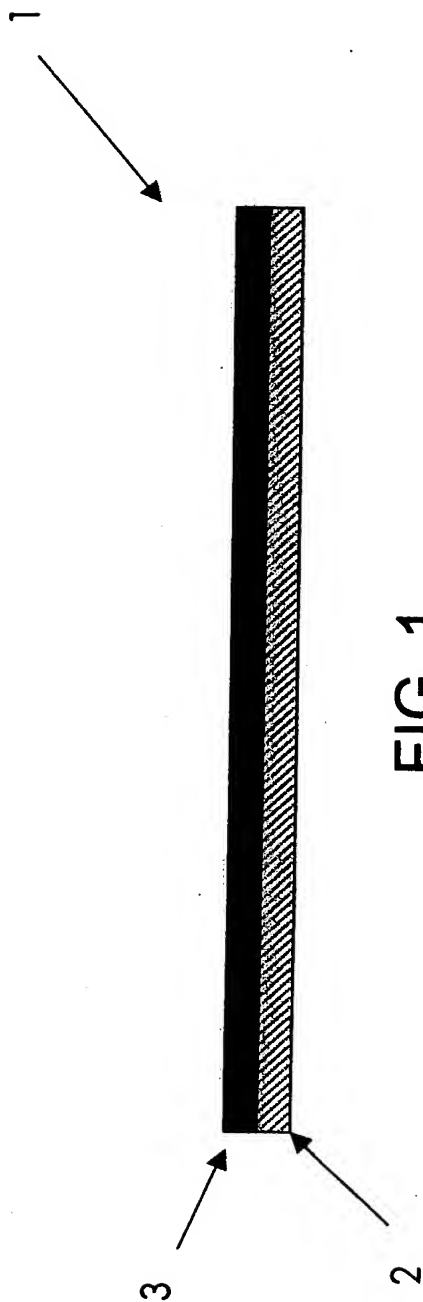


FIG. 1



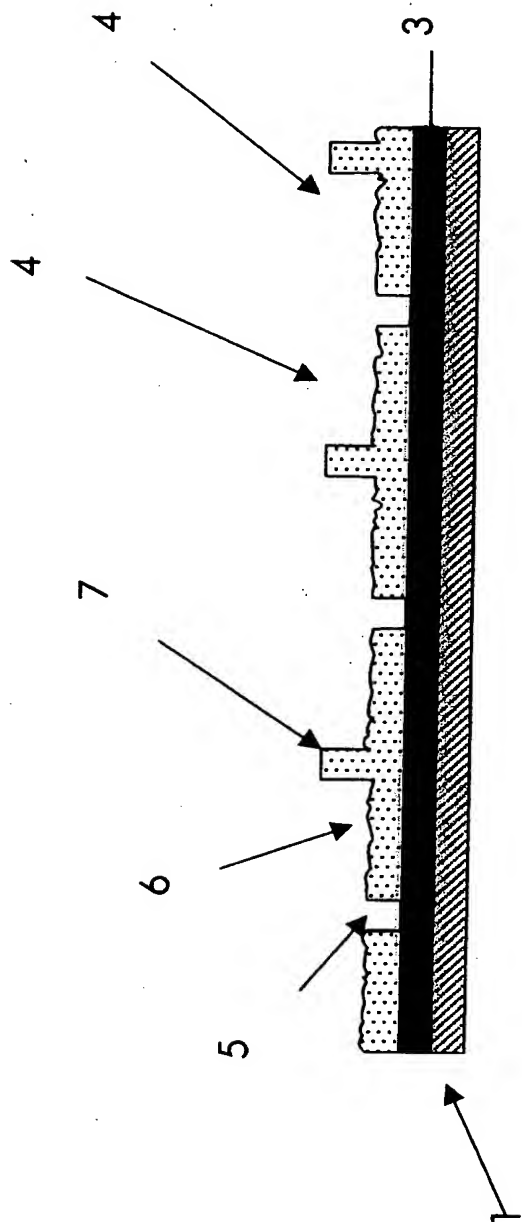


FIG. 2



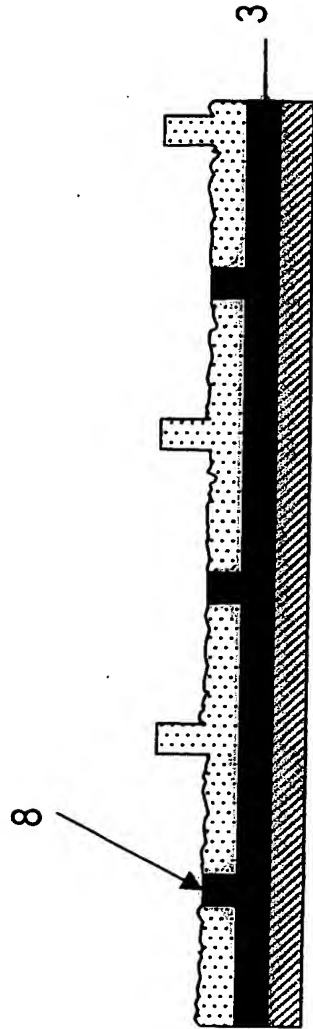


FIG. 3

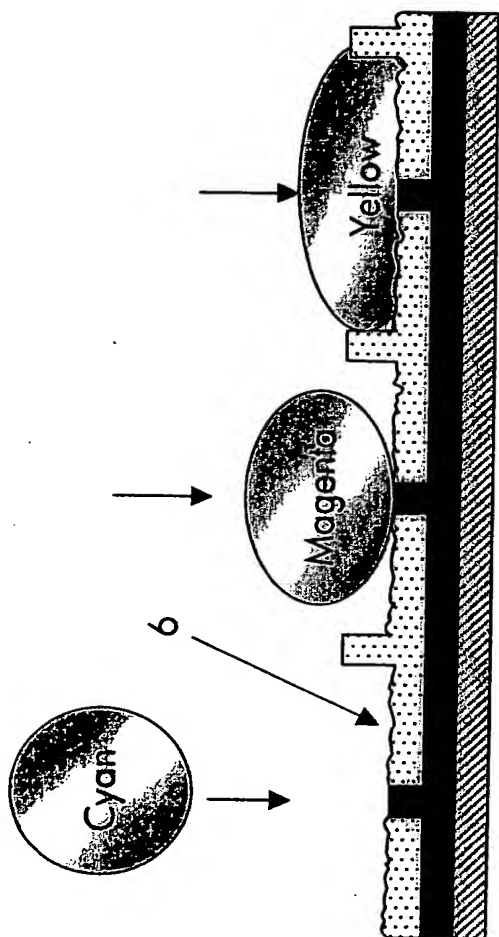


FIG. 4



5/25

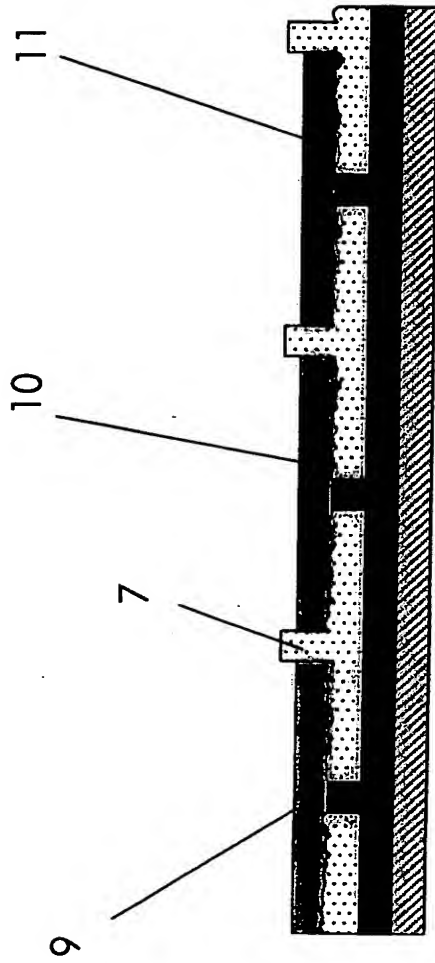
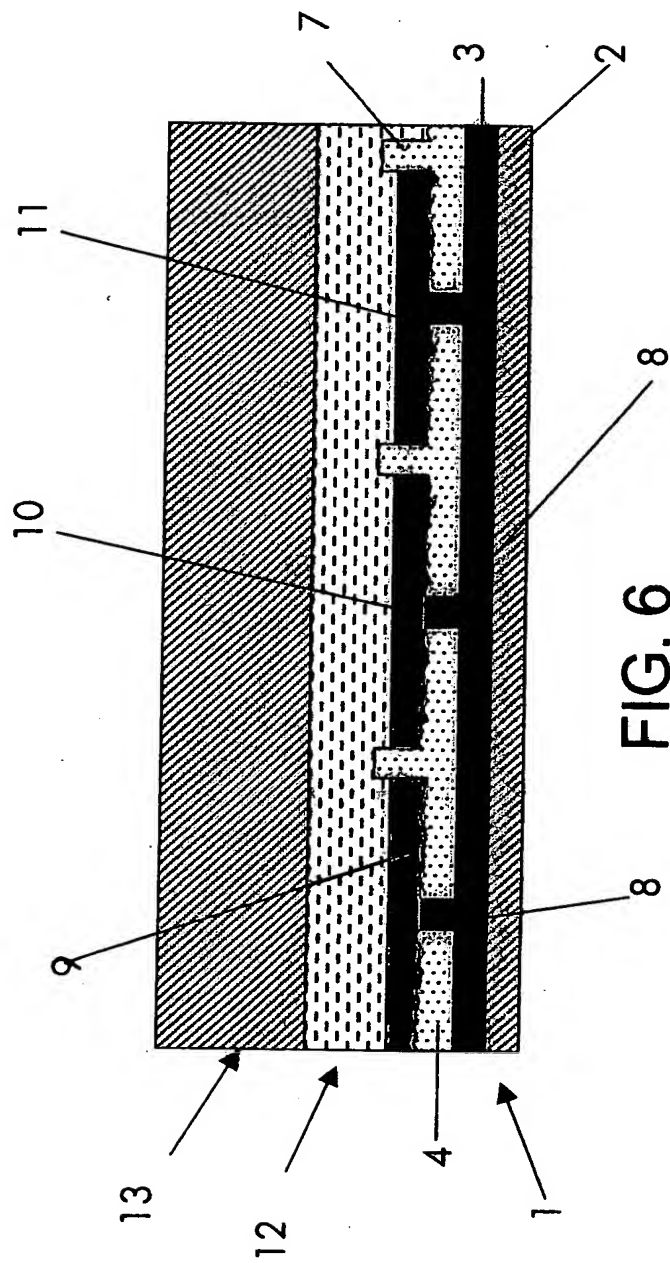


FIG. 5



6/25





7/25

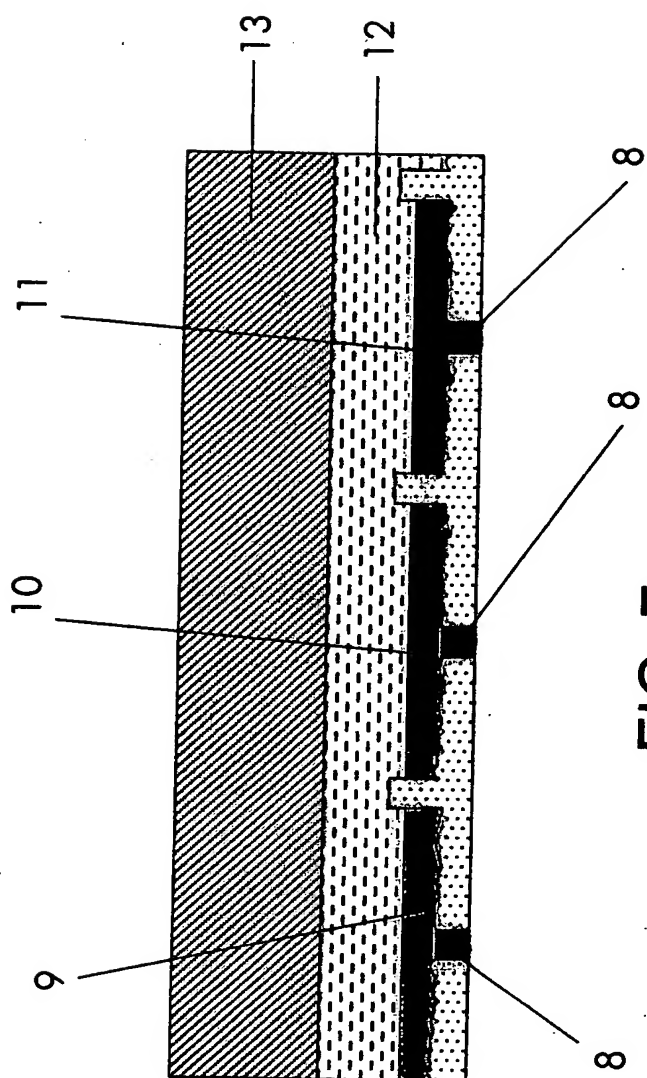


FIG. 7

8/25

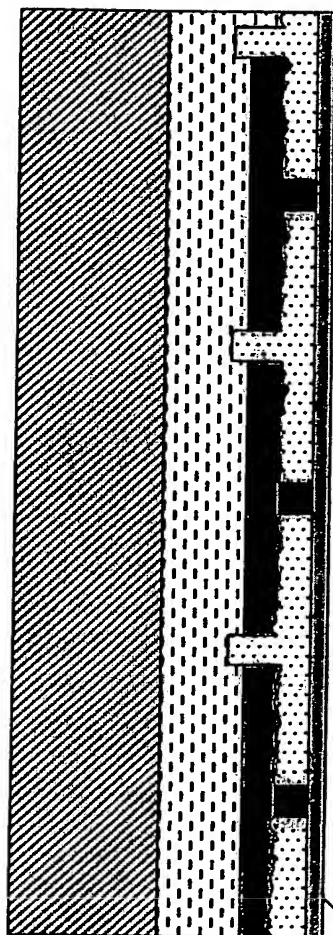


FIG. 8

14

9/25

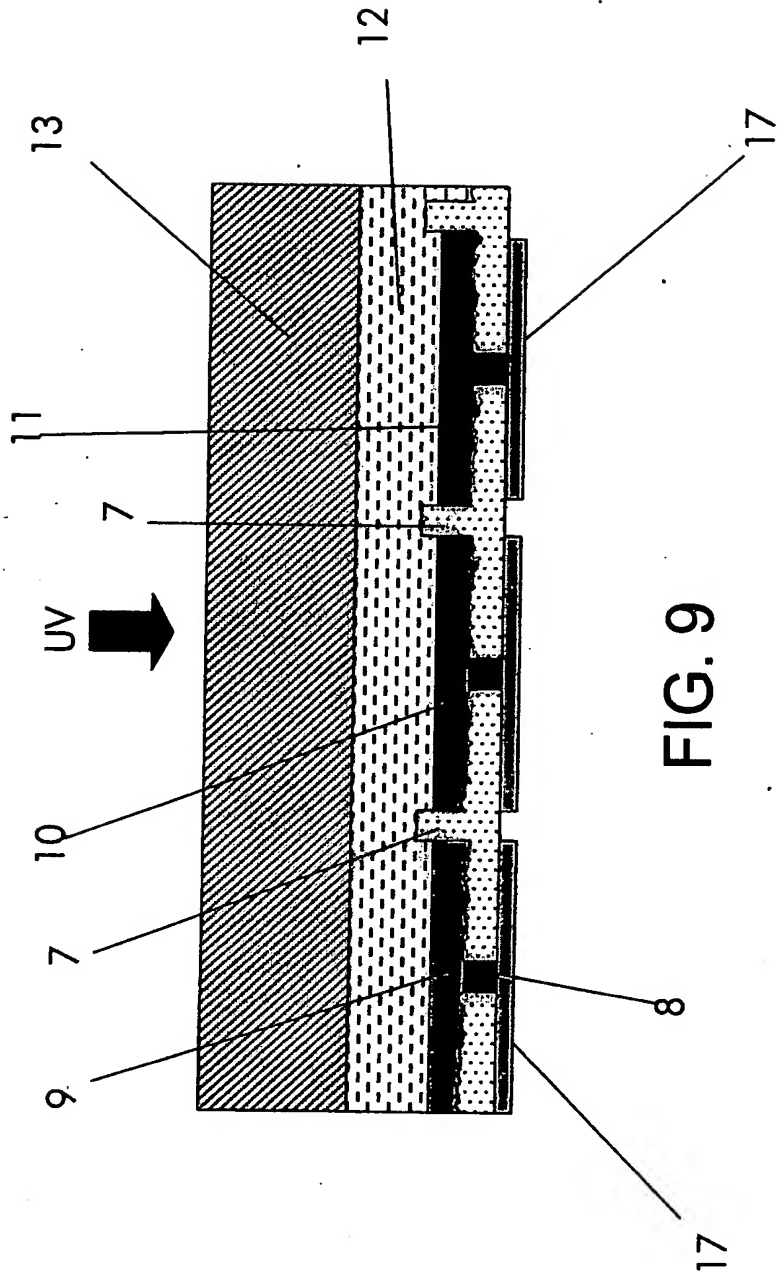


FIG. 9

10/25

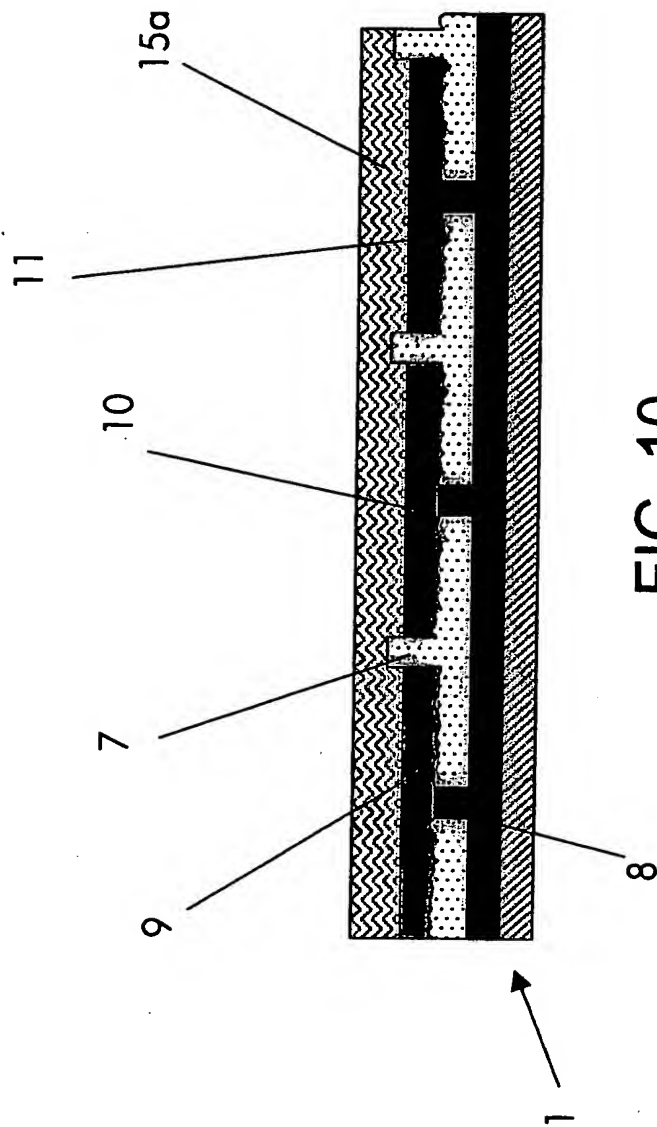


FIG. 10

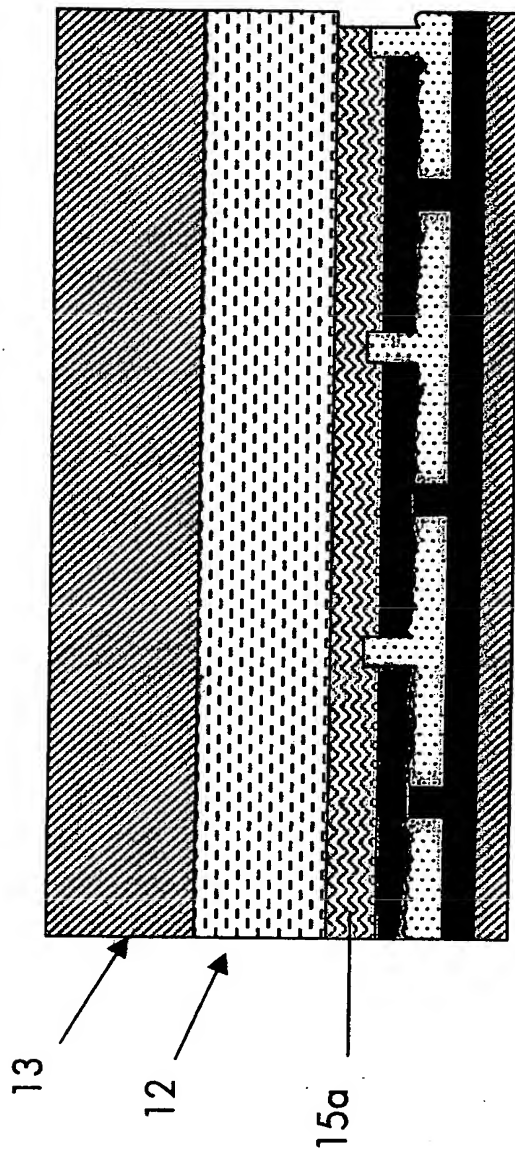


FIG. 11

12/25

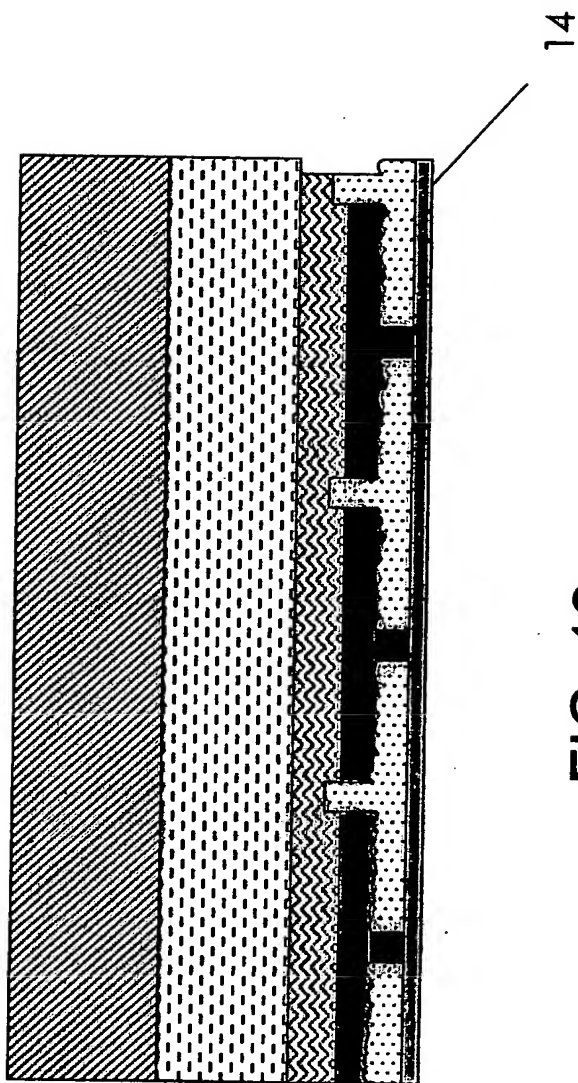


FIG. 12

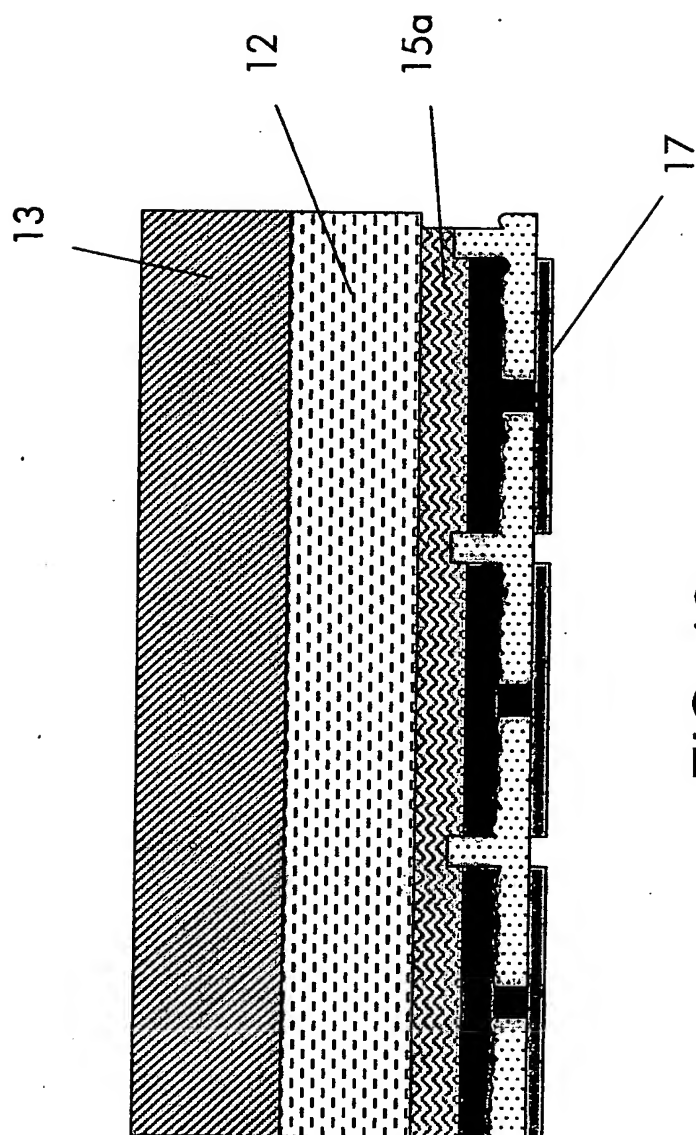


FIG. 13

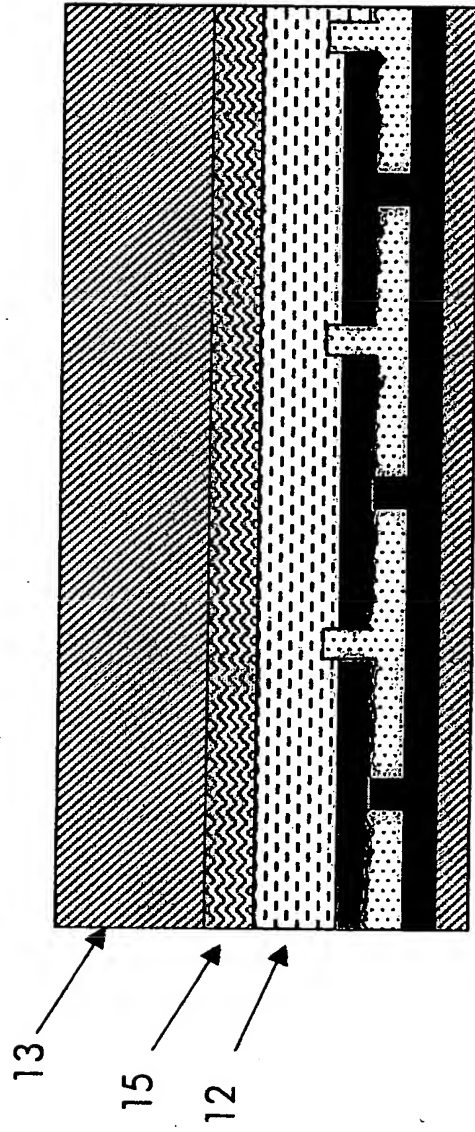


FIG. 14

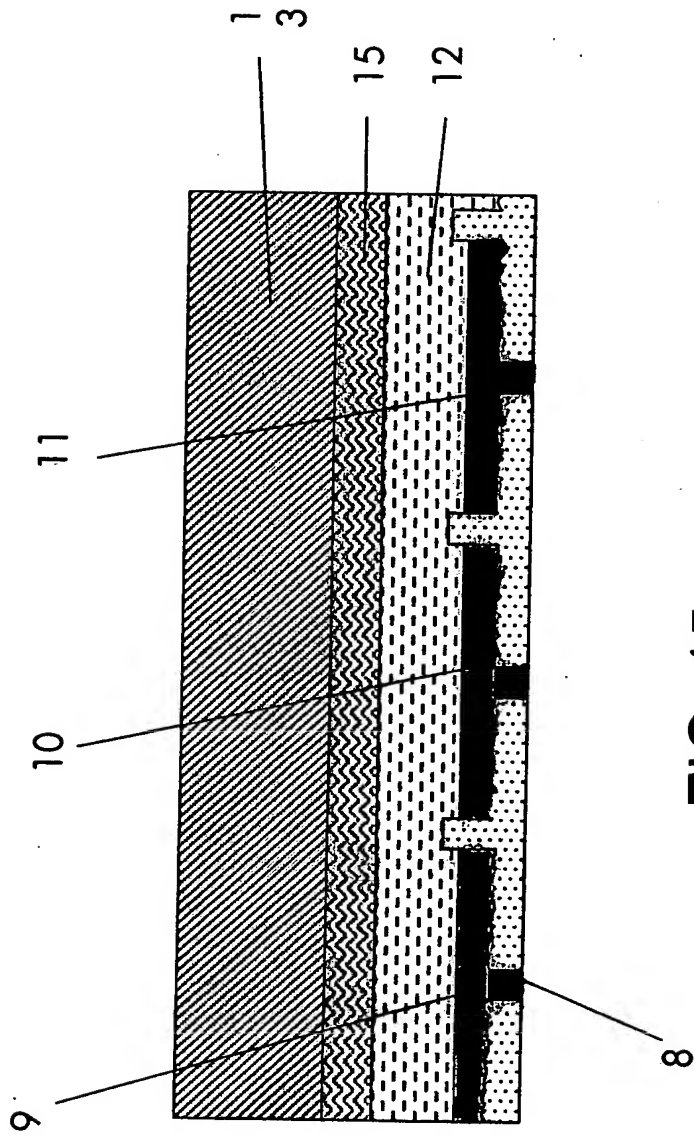


FIG. 15

16/25

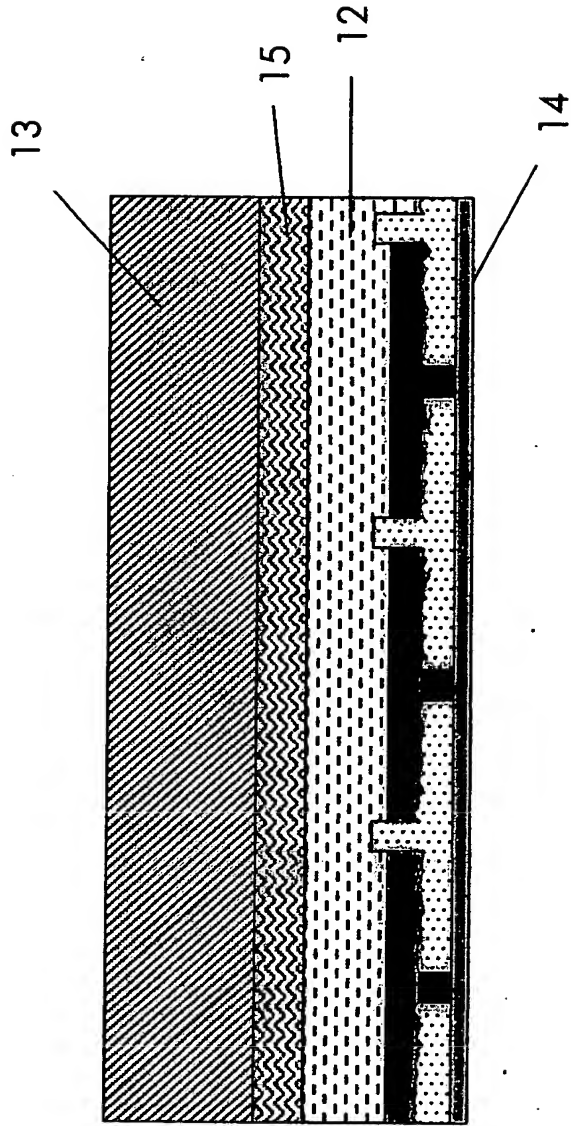
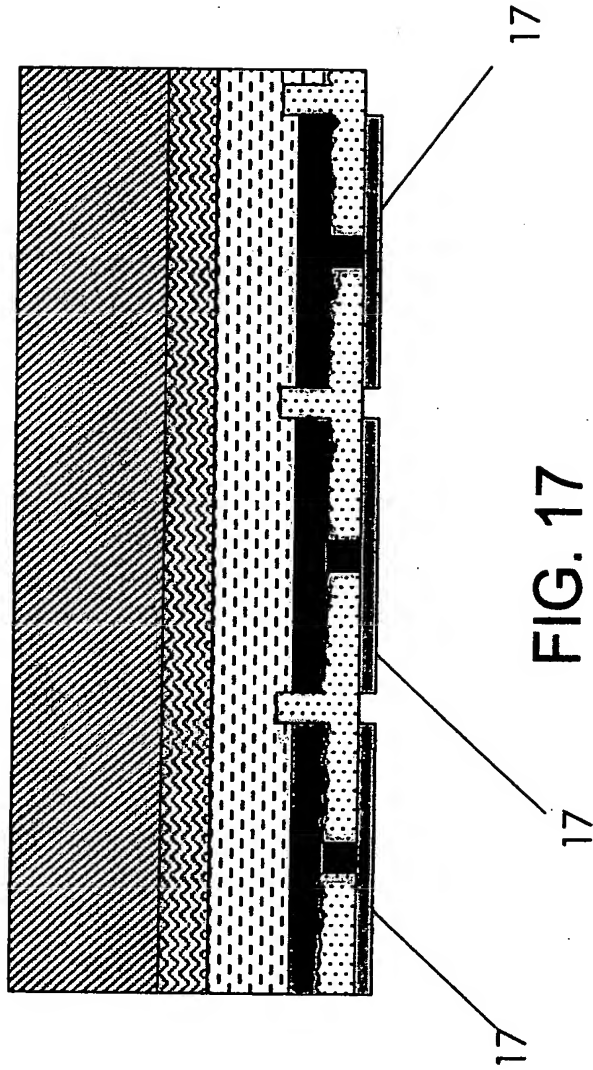


FIG. 16



18/25

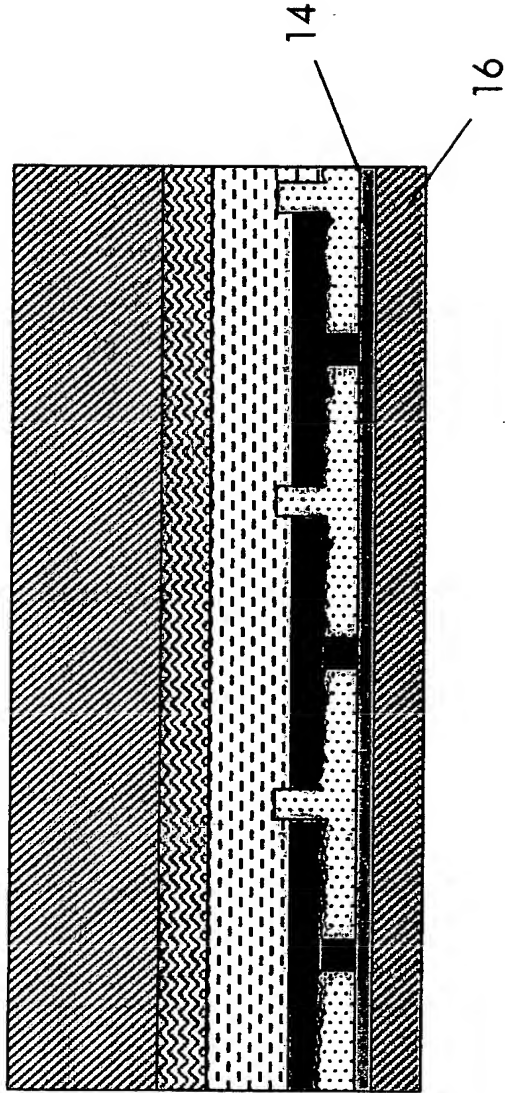


FIG. 18

19/25

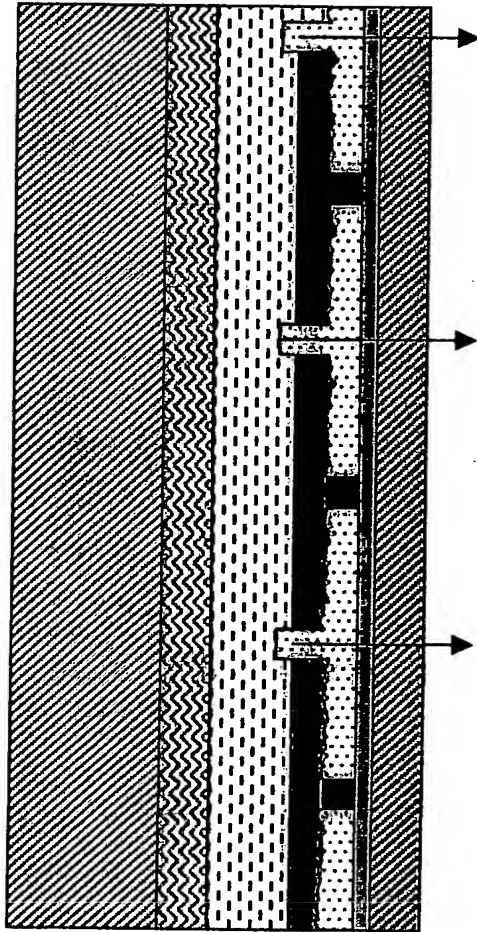
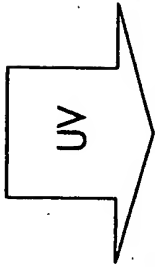
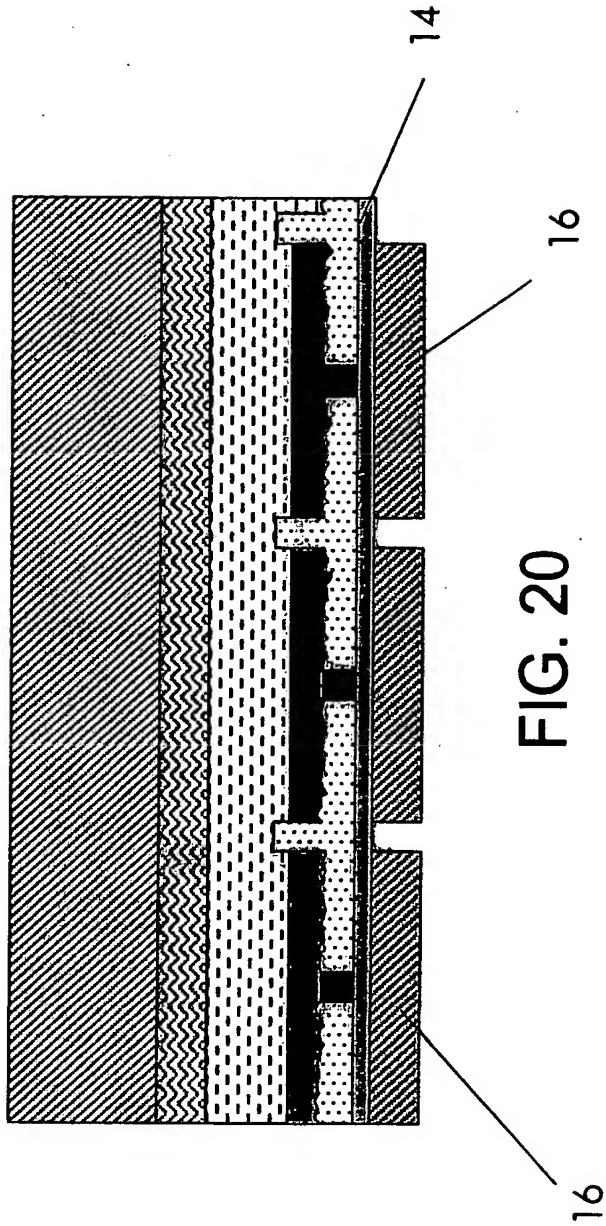


FIG. 19



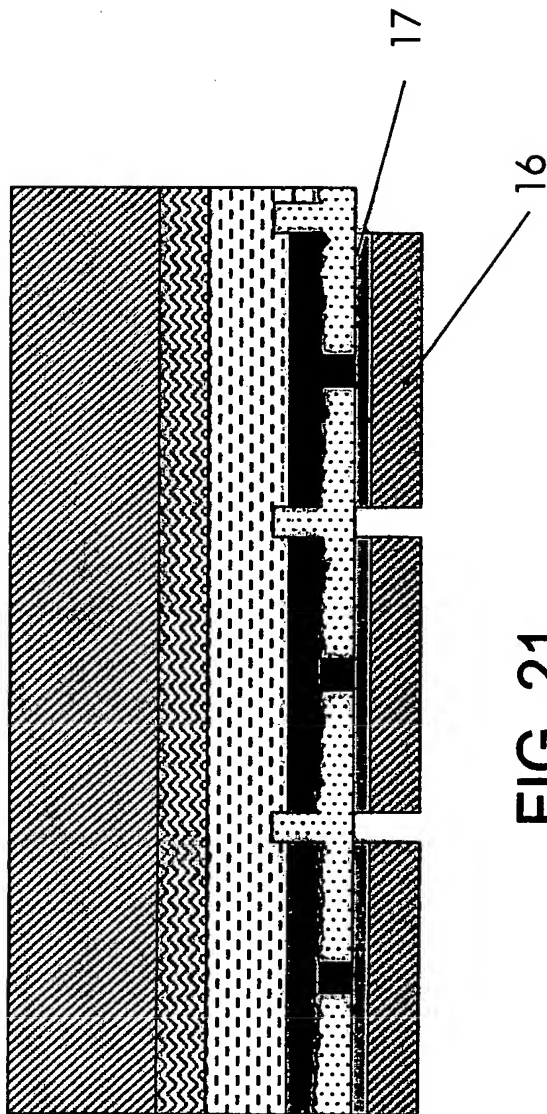


FIG. 21

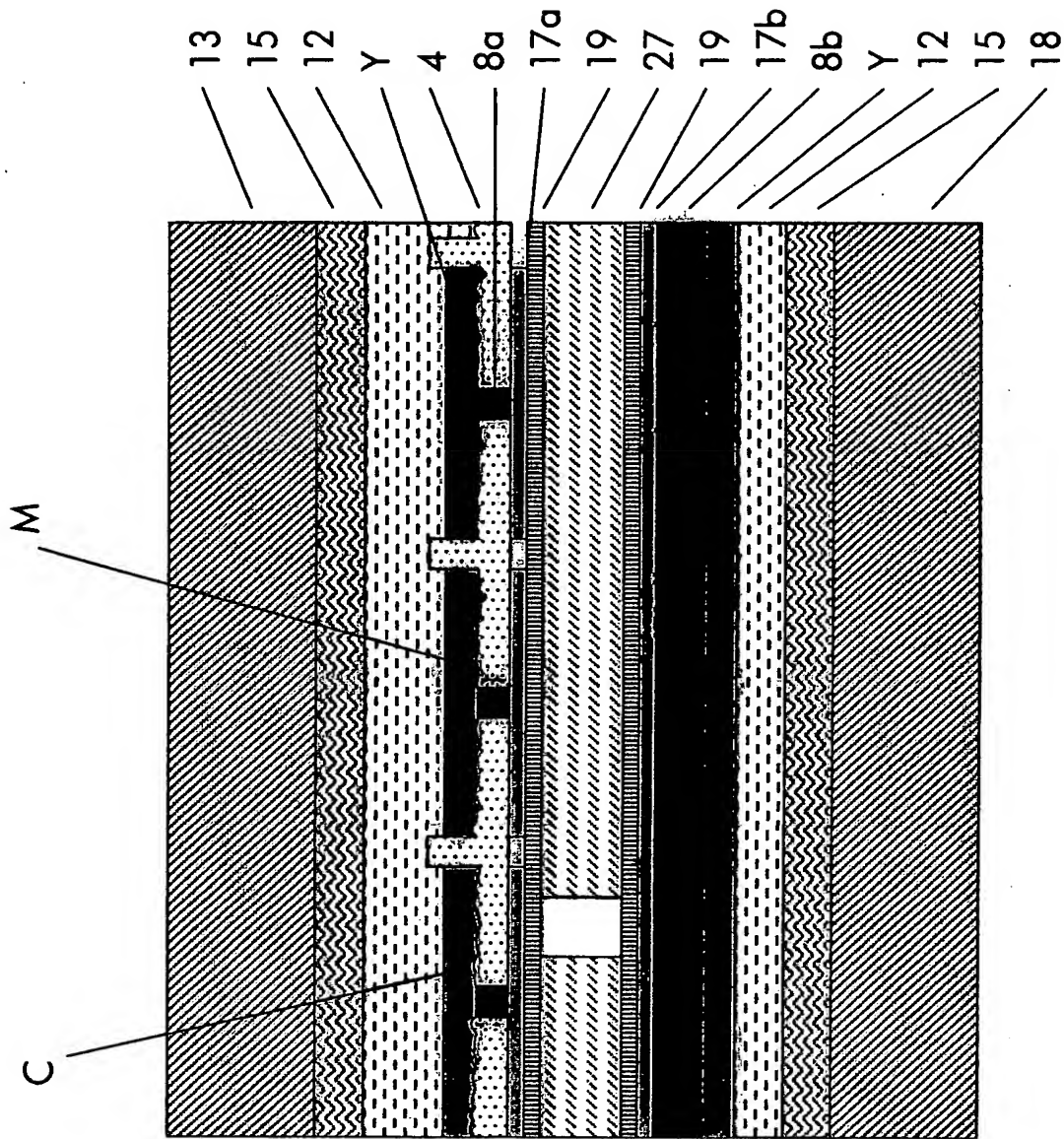


FIG. 22

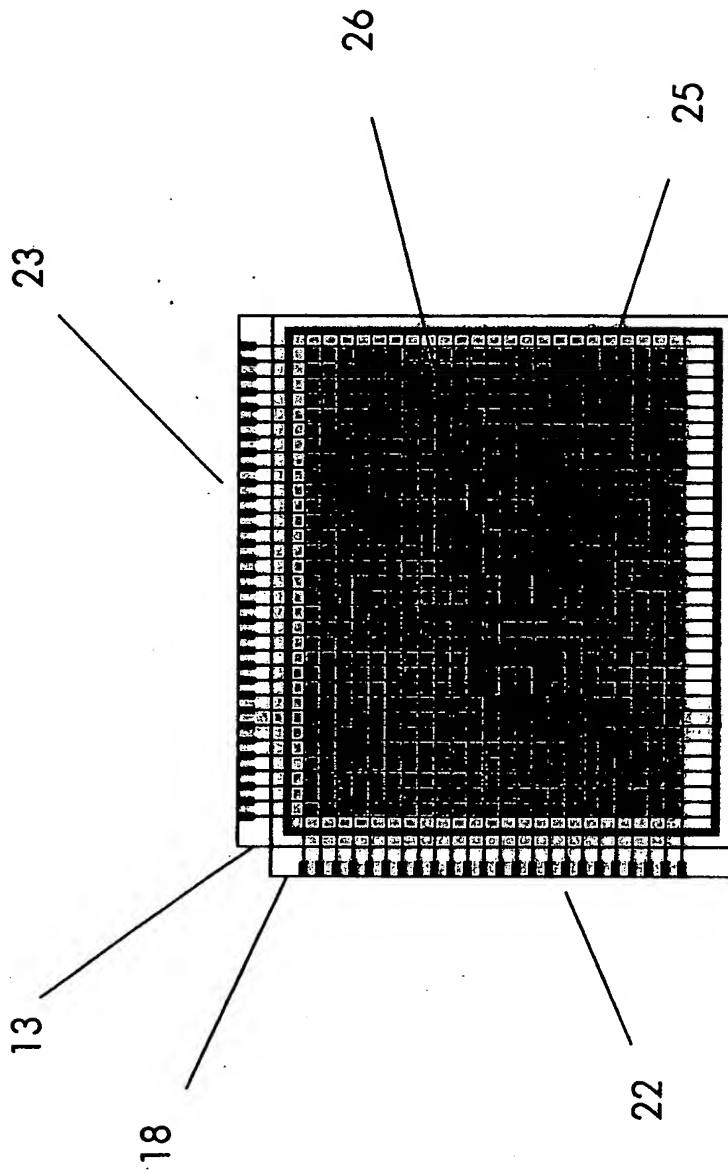


FIG. 23

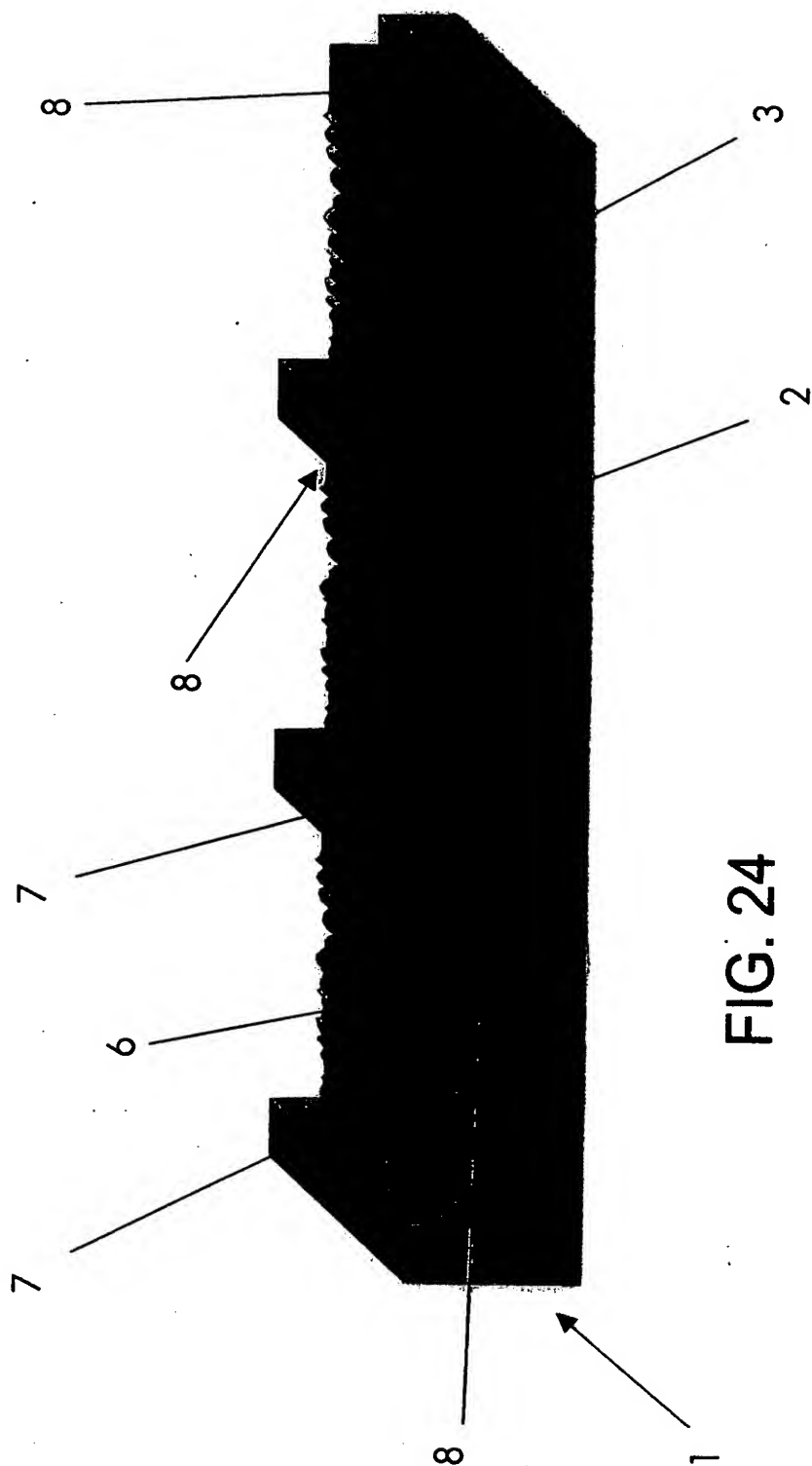


FIG. 24

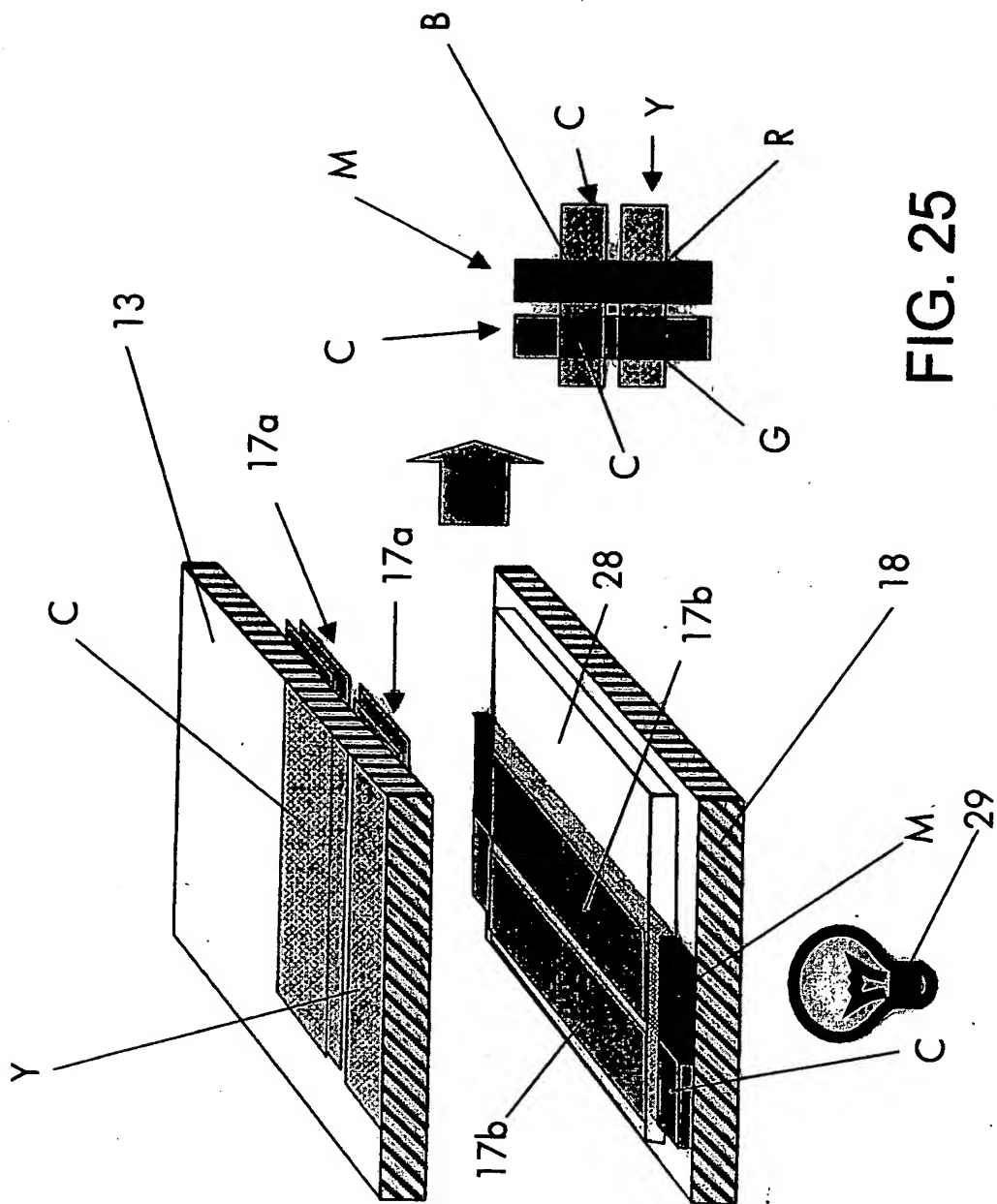


FIG. 25